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Progress towards eliminating industrially produced trans-fatty acids in the Canadian marketplace, 2013–2017

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Abstract

Objective: To assess the prevalence of partially hydrogenated oils (PHO), hydrogenated oils (HO) and/or both in Canadian packaged foods in 2013 and 2017 and to determine the mean trans-fatty acid (TFA) content of products declaring such oils.

Design: Repeated cross-sectional study of the Food Label Information Program.

Setting: Food labels (*n* 32 875) were collected from top Canadian grocery retailers in 2013 and 2017. Proportions of products declaring PHO, HO and/or both in the Ingredients List were calculated by year and food category. The percentage contribution of TFA (g) to total fat (g) was calculated and compared against the voluntary TFA limits, defined as <2 % of total fat content for fats and oils, and <5 % for all other foods. Foods exceeding limits were identified. The mean TFA content (in g/serving and per 100 g) was calculated for products with these oils.

Results: The use of PHO, HO and/or both significantly decreased in Canadian foods from 2013 to 2017 (0·8 to 0·2 %, 5 to 2·4 % and 5·7 to 2·6 %, respectively, for PHO, HO and/or both). The mean TFA content of products containing PHO increased (0·34 to 0·57 g TFA/serving); although it was not statistically significant, it is still concerning that TFA content increased. The TFA content significantly decreased in foods with HO (0·24 to 0·16 g TFA/serving, $P < 0·05$) during 2013–2017.

Conclusions: Products with PHO continue to be present in the Canadian marketplace, despite voluntary efforts to eliminate them. Products with HO should also be monitored, as they can also contribute to TFA content in foods.

Keywords
Trans-fatty acids
Partially hydrogenated oils
Hydrogenated oils
Food labelling
Food supply
Canada

Dietary trans-fatty acids (TFA) are strongly associated with adverse cardiovascular effects, even at low levels of intake[1–3]. Naturally occurring TFA produced by the action of bacteria in the stomach of ruminants (rTFA)[1,4] have reported minimal health risks[2,5,6], although more recent publications[7,8] conflict with previous findings, contributing to a lack of consensus among experts on the effect of rTFA on health. In contrast, health effects of industrially produced TFA (iTFA) are well established[7,8]. iTFA are produced by incorporating H_2 under high pressure and temperatures into the double bonds of unsaturated fatty acids[9,10]. These oils, commonly known as partially hydrogenated oils (PHO), are the main source of TFA in packaged foods[3,11].

Initiatives at reducing TFA in foods began in the early 2000s when the Danish Government limited the use of iTFA to 2 % of total fats, in conjunction with mandatory TFA labelling in the Nutrition Facts[12]. In 2009, the World Health Organization (WHO) Scientific Review on TFA recommended that TFA should be greatly limited or eliminated from the food supply[13], due to their known associations with increased risk of CVD[1–3,14]. Many countries have now taken diverse actions to reduce the content of TFA in foods, including labelling (voluntary or mandatory)[11,15–28] and/or limiting the addition of iTFA in foods[9,11,12,15,29–51] (Fig. 1; detailed information in online Supplemental Table 1). For instance, some Latin American countries introduced similar interventions, which already have shown promising results[17]. In the USA, the Food and Drug Administration determined in 2015 that PHO were no longer generally recognised as safe and therefore prohibiting their use in foods[45]. In 2018, the WHO launched the REPLACE programme, which is an action package and guide aimed at eliminating TFA globally by

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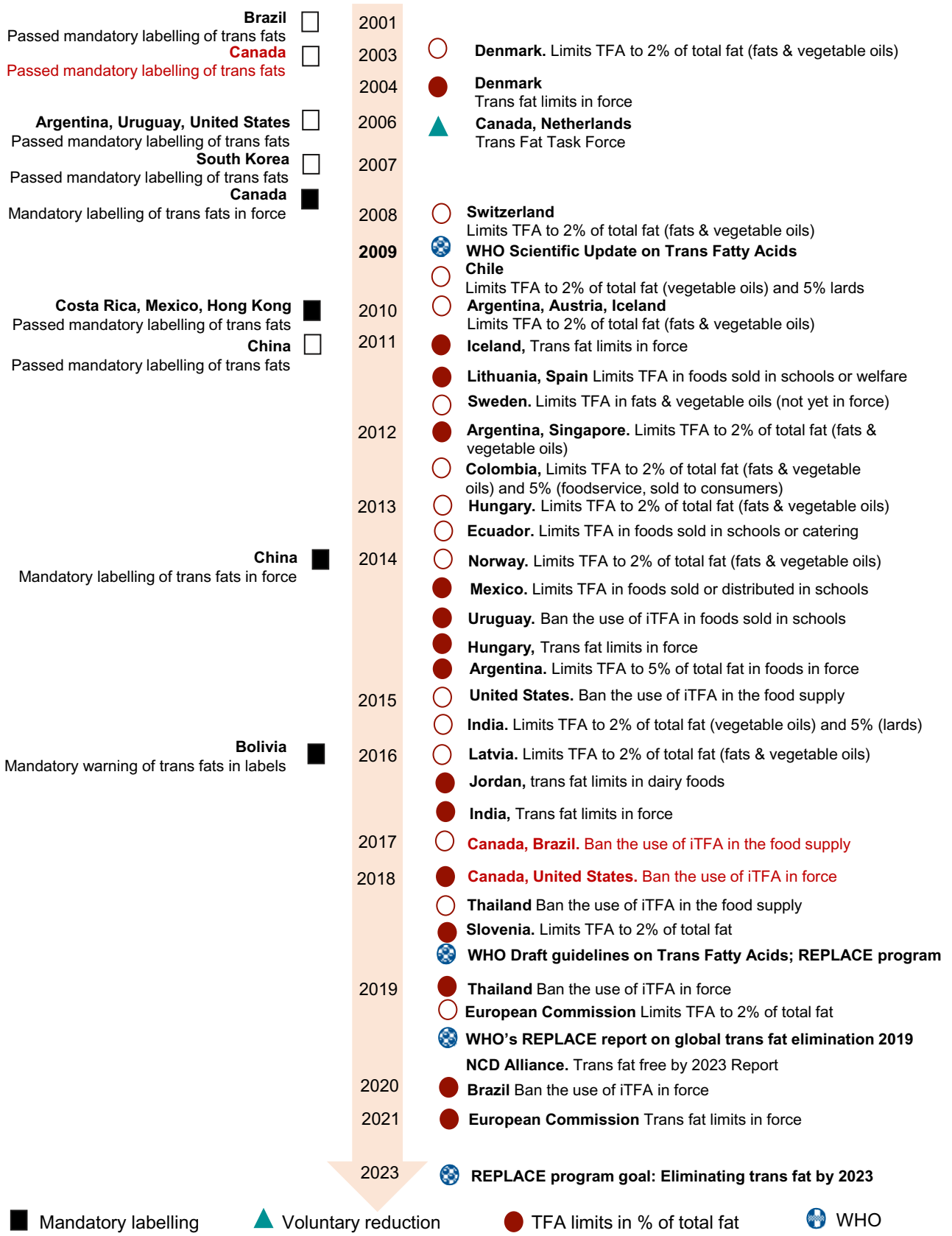

Fig. 1 (colour online) Evolution of interventions aimed at eliminating trans-fatty acids in foods worldwide. Open figure denotes the intervention has passed; full filled figure denotes the intervention is in force

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2023[52], released draft guidelines showing health benefits of TFA intakes <1 % of energy[53] and recently reported worldwide progress[54]. The European Commission also limited TFA in foods by 2021[55]. Four recent systematic reviews have consistently shown that limiting the use of iTFA (i.e. PHO) was the most effective strategy aiming at reducing TFA in foods, while TFA labelling on foods has shown a more limited effectiveness[56–59].

Earlier research in the mid-1990s highlighted that TFA intakes in Canada were among the highest intakes worldwide[60], which led to: (1) mandatory declaration of TFA on the Nutrition Facts table (NFt) in packaged foods and beverages, even if the TFA amount is negligible[19]; (2) the development of voluntary limits on the TFA content in foods, established at <2 % of total fat content for fats and oils, and <5 % for all other foods[29] and (3) creation of the Trans Fat Monitoring Program[61] to conduct periodic monitoring of TFA content in the food supply. Despite these efforts, foods with TFA in 2010 were still found in the Canadian marketplace, and in some cases, at particularly high levels[62]. In September 2017, the Canadian government added PHO, which were defined as 'fats and oils that have been hydrogenated, but not to complete or near complete saturation, and with an iodine value greater than 4'[63], to the List of Contaminants and Other Adulterating Substances in Foods[63] that no longer would be permitted in foods by September 2018[49], an approach already taken by many countries, even though Canada was one of the first countries to mandate the declaration of TFA in the NFt in 2003[19] and set voluntary limits in 2006[29] (Fig. 1). Moreover, fats and oils that have been fully hydrogenated or partially hydrogenated are required in Canada to be labelled as 'hydrogenated vegetable oil' or 'hydrogenated vegetable fat' or 'hydrogenated' along with the specific name of the oil or fat; however, it is not required to identify the nature of the hydrogenation (fully or partially hydrogenated)[64]; therefore, fats and oils that have been labelled only as 'hydrogenated' could also be another potential TFA contributors.

Although the content of TFA in Canadian packaged foods in 2010 has been previously reported[62], little is known about the use of PHO or hydrogenated oils (HO) in the food supply and the levels of TFA associated with their use. The objective of this study was to update data on the prevalence of PHO, HO and/or both in packaged foods collected in 2013 and 2017 and to determine the mean TFA content of products containing such oils. These data can assess the overall progress towards the elimination of TFA in Canada and provide baseline data prior to the prohibition of PHO, which came in force in September 2018.

Methods

Food Label Information Program database

This analysis was a repeated cross-sectional study of the Food Label Information Program (FLIP) databases 2013 and 2017. FLIP is a food label database containing label information of Canadian packaged foods, created and maintained at the University of Toronto. The purpose of FLIP is to monitor and evaluate changes in nutritional quality and label information of foods and beverages in Canada[65]. Three collections of FLIP have been completed with the following number of unique products per collection: FLIP 2010/2011 (n 10 487)[65], FLIP 2013 (n 15 342)[66] and FLIP 2017 (n 17 671), for which details of the 2017 collection are outlined in this paper.

Data collection

FLIP 2017 followed similar collection methods as those established for 2013[66]. Data on prepackaged foods and beverages were collected from the top selling grocery retailers using a mobile data collector app. FLIP 2013 data were collected in the Greater Toronto Area, Ottawa and Calgary during May to September 2013 (Loblaws, Metro, Sobeys and Safeway)[66], while 2017 data were collected during July and September 2017 from Loblaws, Metro and Sobeys in the Greater Toronto Area. Together, these chains represented 75[66] and 68 %[67] of grocery retail sales in Canada for 2013 and 2017, respectively. A mobile data collector app and web-based software and database, developed by researchers at the University of Toronto with technical support from Dietitians of Canada, were used to collect, store and analyse photos of food packages and label data[66] (online Supplemental Fig. 1). Grocery store shelves were systematically scanned, from which universal product codes and photographs of product labels were taken (i.e. front-of-pack, back-of-pack, right side, left side, top, bottom, ingredients close-up, NFt close-up, barcode and shelf tag (regular price)) using the mobile collector app. Every food and beverage with an NFt was included for collection. Food products sold at multiple retailers (e.g. national brand products) were captured only once[66]. Although multiple package sizes of the same product were collected and linked in 2017, products were counted only once in the present study. All flavours and varieties of a product were collected and evaluated. Products were excluded if they were natural health products (e.g. supplements in pill format, protein powders), seasonal products (e.g. Easter chocolates), gum, herbs and spices (e.g. cinnamon, unless it was prepackaged mix such as a steak spice), plain water and any product without a mandatory NFt (e.g. breads baked in-store), as previously established[66].

Data entry and matching

Basic data, including product name, company, NFt (*as purchased*), Ingredients List, price, brand, container size and universal product code, were entered by trained staff onto the FLIP web-based database platform[66]. Products that were present in both collections were matched through their universal product codes, although not used or reported in this paper.

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Data processing and validation

Likewise in 2013[66], if products in FLIP 2017 required preparation before consumption (e.g. canned soups, muffin mixes), nutrition information was calculated *as consumed* using the ESHA Food Processor software and food composition data from the Canadian Nutrient File, which is the standard reference food composition database of nutrients in foods commonly consumed in Canada[68]. Grams/millilitres conversions were also calculated based on similar products and/or the Canadian Nutrient File. Quality assurance measures, including Atwater calculations and data entry verification by a second team member, were conducted to ensure data completeness and accuracy. Products (2013 and 2017) were classified into twenty-four food categories, as defined by the Table of Reference Amounts[69].

Identification and classification of partially hydrogenated oils and hydrogenated oils

For the purpose of this study, we classified PHO 'as those hydrogenated fats and oils, specifically labelled as partially hydrogenated' and HO 'as hydrogenated fats and oils without level of hydrogenation specified'. The presence of PHO and HO was determined in foods using the Ingredients List. Terms that were searched for in the Ingredients List included *partially hydrogenated vegetable oil*, *hydrogenated vegetable oil* or any other variations of these using different types of oils (e.g. rapeseed, soyabean, sunflower and cottonseed), or any vegetable fat that was labelled as *partially hydrogenated or hydrogenated*.

Analyses

From 33 013 unique products collected in 2013 and 2017, meal replacements (n 137) and natural health products (n 1) were excluded for analysis, giving a total of 32 875 products analysed in this study. Proportions of products containing PHO, HO or both were calculated by year and by TRA food category[69]. The percentage contribution of TFA (g) to total fat (g) was calculated and compared against the recommended limits, defined as <2 % of total fat content for fats and oils, and <5 % for all other foods. Foods exceeding such limits were identified[29]. The mean TFA content (declared as g TFA/serving on the NFt) was calculated for products declaring PHO, HO or both and stratified by level of TFA content: (a) ≤0 g TFA/serving in the NFt, (b) products with >0 g TFA/serving in the NFt but not exceeding TFA limit and (c) products exceeding TFA recommended limits. χ^2 (or Fisher test) and Mann–Whitney–Wilcoxon tested for differences in proportions and mean TFA content of products carrying these oils between years. Analyses were conducted using R-Studio[70].

Results

The use of PHO, HO or both has significantly decreased in the Canadian food supply from 2013 to 2017 (Table 1). Overall, PHO use was reduced from 0·8 (n 117/15 286) to 0·2 % (n 36/17 589), HO use decreased from 5 % (n 766/15 286) to 2·4 % (n 419/17 589) and the use of PHO, HO and/or both in foods also decreased from 5·7 % (n 871/15 286) to 2·6 % (n 450/17 589), respectively, for 2013 and 2017 (all $P < 0·001$). The largest decrease in the use of PHO was seen in desserts (2·7–0 %), salads (2·9–0·8 %) and combination dishes (1·9–0 %), all significant ($P \leq 0·004$). The use of HO was reduced mostly in potatoes, sweet potatoes and yams from 16·4 to 1·5 %, combination dishes from 10·3 to 2 % and desserts from 11·7 to 4 % (all $P < 0·001$). However, we also observed an increase in the use of HO in dessert toppings and fillings from 10·2 to 13·8 %, although it was not statistically significant. We also found twelve foods that had both PHO and HO declared in the Ingredients List. The mean TFA per food category is also shown in Table 1. Although for most food categories, the TFA content decreased for foods with PHO between 2013 and 2017, we observed a significant increase in bakery products ($P = 0·03$). We also observed an increasing but not statistically significant trend in the mean TFA of products with HO in the following categories: dessert topping and fillings, fats and oils and salads (due to the accompanying dressings). The mean TFA content of products containing PHO slightly increased (0·34 to 0·57 g TFA/serving), but it was not statistically significant. The TFA content significantly decreased in foods with HO (0·24 to 0·16 g TFA/serving, $P < 0·05$) from 2013 to 2017 (Table 2).

Discussion

In light of the recent ban of PHO in Canadian foods, this study assessed the prevalence of PHO, and HO and/or both in packaged foods, and the mean TFA levels of products containing such oils, sold in 2013 and 2017, before the regulations were fully in force in 2018. Analyses showed encouraging results towards the elimination of PHO as 0·2 % of foods in 2017 contained such oils, which represents a quarter of the prevalence observed in 2013 (0·8 %). HO were also less often used in 2017 compared with 2013 (5–2·4 %). These results are consistent with other studies that have observed a decrease in the use of fats and oils containing TFA in recent years[71–73]. Although for most food categories, a decrease in the use of PHO and HO also showed a decrease in the mean TFA content, we found that in the bakery category, products with PHO, the amount of TFA significantly increased from 0·88 to 2·99 g/100 g in 2017. Data from other countries showed that products within similar categories, such as pastries, cookies and other bakery products, presented levels ranging from 0·03 to 0·78 g/100 g[71,72]. Therefore, our finding is

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Table 1 Prevalence of foods and beverages declaring partially hydrogenated oils (PHO), hydrogenated oils (HO) and/or both in the Ingredients List and trans-fatty acid (TFA) levels in Food Label Information Program (FLIP) 2013 and 2017 by food category (*n* 32 875)

	FLIP 2013 (*n* 15 286)							FLIP 2017 (*n* 17 589)							
	Total			g/serving		g/per 100 g		Total			g/serving		g/per 100 g		
	n	*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI	*n*	*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI	*P**
Foods with partially hydrogenated oils															
TRA food category†															
Bakery products	2097	21	1·0	0·54	0·18, 0·90	0·88	0·40, 1·35	2775	13	0·5	1·15	0·66, 1·63	2·99	1·44, 4·53	<0·001
Beverages	482	1	0·2	0	n/a	0	n/a	852	0	0·0	n/a		n/a		0·23
Cereals and other grain Products	1126	6	0·5	0·10	–0·08, 0·28	0·22	–0·24, 0·69	1276	3	0·2	0·07	–0·22, 0·35	0·07	–0·24, 0·39	0·32
Dairy products and substitutes	1224	11	0·9	0·91	0·54, 1·24	4·84	3·34, 6·34	1498	2	0·1	2	n/a	6·67	n/a	0·001
Desserts	829	22	2·7	0·12	0·05, 0·19	0·01	–0·01, 0·02	679	0	0·0	n/a		n/a		<0·001
Dessert toppings and fillings	118	1	0·8	2	n/a	6·67	n/a	94	0	0·0	n/a		n/a		1
Egg and egg substitutes	56	1	1·8	0	n/a	0	n/a	61	0	0·0	n/a		n/a		0·47
Fats and oils	537	0	0·0	n/a		n/a		656	0	0·0	n/a		n/a		–
Marine and fresh water animals	442	0	0·0	n/a		n/a		446	0	0·0	n/a		n/a		–
Fruit and fruit juices	1078	1	0·1	0	n/a	0	n/a	1061	0	0·0	n/a		n/a		0·001
Legumes	182	0	0·0	n/a		n/a		188	0	0·0	n/a		n/a		–
Meat, poultry and substitutes	910	4	0·4	0·43	–0·72, 1·57	0·31	–0·51, 1·12	962	2	0·2	0·05	–0·59, 0·69	0·05	–0·59, 0·69	0·02
Miscellaneous category	476	6	1·3	0	n/a	0	n/a	578	4	0·7	0	n/a	0	n/a	0·43
Combination dishes	1231	23	1·9	0·43	0·17, 0·69	0·22	0·12, 0·32	1139	0	0·0	n/a		n/a		<0·001
Nuts and seeds	202	0	0·0	n/a		n/a		256	0	0·0	n/a		n/a		–
Potatoes, sweet potatoes and yams	140	3	2·1	0	n/a	0	n/a	132	1	0·8	0	n/a	0	n/a	0·62
Salads	70	2	2·9	0·30	0·30, 0·30	1·36	1·36, 1·36	131	1	0·8	0·20	n/a	0·9	n/a	0·004
Sauces, dips, gravies and condiments	1246	3	0·2	0	n/a	0	n/a	1250	1	0·1	0	n/a	0	n/a	0·37
Snacks	746	4	0·5	0·05	–0·11, 0·21	0·10	–0·22, 0·42	866	1	0·1	0·01	n/a	0·25	n/a	0·19
Soups	457	0	0·0	n/a		n/a		480	2	0·4	0·05	–0·59, 0·59	0·06	–0·68, 0·80	0·50
Sugars and sweets	796	7	0·9	0·11	0·05, 0·18	0·32	0·09, 0·55	1109	6	0·5	0·13	0·02, 0·24	0·35	0·07, 0·63	0·55
Vegetables	839	1	0·1	0	n/a	0	n/a	871	0	0·0	n/a		n/a		–
Foods intended solely for children <4 years	2	0	0·0	n/a		n/a		229	0	0·0	n/a		n/a		–
Total	15 286	117	0·8	0·34	0·24, 0·44	0·85	0·52, 1·18	17 589	36	0·2	0·57	0·30, 0·83	1·55	0·74, 2·36	<0·001
Foods with hydrogenated oils															
TRA food category†															
Bakery products	2097	156	7·4	0·18	0·14, 0·23	0·49	0·34, 0·64	2775	116	4·2	0·13	0·07, 0·19	0·27	0·14, 0·40	<0·001
Beverages	482	11	2·3	0·03	–0·02, 0·07	0·23	–0·13, 0·60	852	22	2·6	0	0, 0·01	0·01	–0·01, 0·03	0·40
Cereals and other grain products	1126	47	4·2	0·03	0, 0·06	0·08	0·01, 0·16	1276	40	3·1	0·01	–0·01, 0·03	0·03	–0·02, 0·08	0·21
Dairy products and substitutes	1224	40	3·3	0·02	0, 0·03	0·45	–0·11, 1·01	1498	13	0·9	0·01	–0·01, 0·02	0·02	–0·02, 0·06	<0·001
Desserts	829	97	11·7	0·11	0·08, 0·13	0·02	0, 0·04	679	27	4·0	0·22	0, 0·45	0		<0·001
Dessert toppings and fillings	118	12	10·2	1·17	0·66, 1·68	3·31	1·83, 4·79	94	13	13·8	1·12	0·44, 1·79	3·42	1·37, 5·46	0·54
Egg and egg substitutes	56	0	0·0	n/a		n/a		61	0	0·0	n/a		n/a		–
Fats and oils	537	10	1·9	1·79	0·69, 2·89	18·00	7·08, 28·92	656	7	1·1	1·89	0·28, 3·49	18·93	2·92, 34·94	0·23
Marine and fresh water animals	442	1	0·2	0	n/a	0	n/a	446	1	0·2	0	n/a	0	n/a	1
Fruit and fruit juices	1078	4	0·4	0	n/a	0	n/a	1061	2	0·2	0	n/a	0	n/a	0·003
Legumes	182	0	0·0	n/a		n/a		188	0	0·0	n/a		n/a		–
Meat, poultry and substitutes	910	11	1·2	0·16	–0·03, 0·36	0·17	–0·06, 0·40	962	6	0·6	0·22	–0·19, 0·62	0·07	–0·01, 0·16	0·02

Table 1 *Continued*

	FLIP 2013 (*n* 15 286)							FLIP 2017 (*n* 17 589)							
	Total			g/serving		g/per 100 g		Total			g/serving		g/per 100 g		
	n	*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI		*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI	*P**
Miscellaneous category	476	63	13·2	0·13	0·08, 0·18	0·67	0·15, 1·19	578	35	6·1	0·16	0·08, 0·23	0·74	–0·08, 1·57	<0·001
Combination dishes	1231	127	10·3	0·60	0·43, 0·78	0·37	0·28, 0·45	1139	23	2·0	0·17	0·10, 0·25	0·12	0·07, 0·18	<0·001
Nuts and seeds	202	26	12·9	0	n/a	0	n/a	256	25	9·8	0	n/a	0	n/a	0·36
Potatoes, sweet potatoes and yams	140	20	14·3	0·33	0·02, 0·64	0·81	0·33, 1·29	132	2	1·5	0	n/a	0	n/a	<0·001
Salads	70	4	5·7	0·18	–0·15, 0·50	0·14	–0·16, 0·44	131	4	3·1	0·55	0·07, 1·03	0·29	0·09, 0·49	0·008
Sauces, dips, gravies and condiments	1246	17	1·4	0·12	0·04, 0·21	0·74	0·27, 1·21	1250	2	0·2	0·05	–0·59, 0·69	0·08	–0·93, 1·09	<0·001
Snacks	746	39	5·2	0·19	–0·03, 0·41	0·42	–0·07, 0·91	866	22	2·5	0·09	0·03, 0·16	0·19	0·05, 0·34	0·007
Soups	457	20	4·4	0·15	–0·07, 0·36	0·06	–0·68, 0·80	480	7	1·5	0	n/a	0	n/a	0·01
Sugars and sweets	796	61	7·7	0·12	0·08, 0·16	0·40	0·26, 0·55	1109	52	4·7	0·08	0·06, 0·11	0·23	0·17, 0·30	0·008
Vegetables	839	0	0·0	n/a		n/a		871	0	0·0	n/a		n/a		–
Foods intended solely for children < 4 years	2	0	0·0	n/a		n/a		229	0	0·0	n/a		n/a		–
Total	15 286	766	5·0	0·24	0·20, 0·29	0·71	0·49, 0·93	17 589	419	2·4	0·16	0·12, 0·21	0·63	0·30, 0·97	<0·001
Foods with partially hydrogenated oils, hydrogenated oils and/or both TRA food category†															
Bakery products	2097	174	8·3	0·23	0·17, 0·29	0·54	0·40, 0·68	2775	127	4·6	0·21	0·13, 0·29	0·48	0·26, 0·70	<0·001
Beverages	482	12	2·5	0·03	–0·01, 0·06	0·21	–0·12, 0·55	852	22	2·6	0	0, 0·01	0·01	–0·01, 0·03	0·42
Cereals and other grain products	1126	53	4·7	0·04	0·01, 0·07	0·10	0·02, 0·17	1276	43	3·4	0·02	0, 0·04	0·04	–0·01, 0·08	0·11
Dairy products and substitutes	1224	51	4·2	0·21	0·09, 0·33	1·40	0·58, 1·24	1498	15	1·0	0·27	–0·12, 0·66	0·97	–0·43, 2·36	0·001
Desserts	829	114	13·8	0·11	0·09, 0·14	0·02	0, 0·03	679	27	4·0	0·22	0, 0·45	0	n/a	<0·001
Dessert toppings and fillings	118	13	11·0	1·23	0·75, 1·72	3·57	2·11, 5·03	94	13	13·8	1·12	0·44, 1·79	3·42	1·37, 5·46	0·68
Egg and egg substitutes	56	1	1·8	0	n/a	0	n/a	61	0	0·0	n/a		n/a		0·47
Fats and oils	537	10	1·9	1·79	0·69, 2·89	18·00	7·08, 28·92	656	7	1·1	1·89	0·28, 3·49	18·9	2·92, 34·94	0·23
Marine and fresh water animals	442	1	0·2	0	n/a	0	n/a	446	1	0·2	0	n/a	0	n/a	1
Fruit and fruit juices	1078	5	0·5	0	n/a	0	n/a	1061	2	0·2	0	n/a	0	n/a	0·002
Legumes	182	0	0·0	n/a		n/a		188	0	0·0	n/a		n/a		–
Meat, poultry and substitutes	910	15	1·6	0·23	0, 0·47	0·20	–0·01, 0·41	962	8	0·8	0·17	–0·11, 0·46	0·07	0·01, 0·13	0·01
Miscellaneous category	476	69	14·5	0·12	0·07, 0·17	0·61	0·14, 1·09	578	38	6·6	0·14	0·07, 0·22	0·69	–0·08, 1·45	<0·001
Combination dishes	1231	149	12·1	0·56	0·41, 0·72	0·34	0·27, 0·42	1139	23	2·0	0·17	0·10, 0·25	0·12	0·07, 0·18	<0·001
Nuts and seeds	202	26	12·9	0	n/a	0	n/a	256	25	9·8	0	n/a	0	n/a	0·36
Potatoes, sweet potatoes and yams	140	23	16·4	0·29	0·01, 0·56	0·71	0·28, 1·14	132	3	2·3	0	n/a	0	n/a	<0·001
Salads	70	6	8·6	0·22	0·04, 0·40	0·55	–0·13, 1·23	131	5	3·8	0·48	0·10, 0·86	0·41	0·04, 0·78	0·01
Sauces, dips, gravies and condiments	1246	20	1·6	0·11	0·03, 0·18	0·63	0·21, 1·04	1250	3	0·2	0·03	–0·11, 0·18	0·05	–0·17, 0·28	0·001
Snacks	746	42	5·6	0·18	–0·02, 0·38	0·40	–0·05, 0·85	866	23	2·7	0·09	0·03, 0·15	0·20	0·06, 0·34	0·003
Soups	457	20	4·4	0·15	–0·07, 0·36	1·35	0·06, 2·64	480	9	1·9	0·01	–0·01, 0·04	0·01	–0·02, 0·04	0·04
Sugars and sweets	796	66	8·3	0·12	0·08, 0·16	0·40	0·27, 0·54	1109	56	5·0	0·09	0·06, 0·11	0·24	0·17, 0·30	0·005
Vegetables	839	1	0·1	0	n/a	0	n/a	871	0	0·0	n/a		n/a		0·04
Foods intended solely for children <4 years	2	0	0·0	n/a		n/a		229	0	0·0	n/a		n/a		–
Total	15 286	871	5·7	0·26	0·22, 0·30	0·74	0·54, 0·93	17 589	450	2·6	0·19	0·14, 0·24	0·69	0·38, 1·01	<0·001

TRA, table of reference amounts.
*Differences in proportions of products carrying PHO, HO and/or both between years were determined using χ^2 test or Fisher test.
†As defined in the TRA[69].

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Table 2 Mean trans-fatty acid (TFA) content of products declaring partially hydrogenated oils (PHO), hydrogenated oils (HO) and/or both in the Ingredients List in Food Label Information Program (FLIP) 2013 and FLIP 2017 stratified by products meeting or exceeding recommendations (*n* 32 875)

	FLIP 2013 (*n* 15 286)								FLIP 2017 (*n* 17 589)							
	Total		g/serving*		*per 100 g*		% TFA *v.* total fat		Total		g/serving*		*per 100 g*		% TFA *v.* total fat	
Type of oil listed in the Ingredients List	*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI			*n*	%	Mean TFA	95 % CI	Mean TFA	95 % CI		
Foods with PHO†	117		0·34	0·24, 0·44	0·85	0·52, 1·18	7	4, 10	36		0·57	0·30, 0·83	1·55	0·74, 2·36	8	4, 12
Foods ≤ 0 g/serving TFA	51	44	0	n/a	0	n/a	0		13	36	0	n/a	0	n/a	0	
Foods > 0 g/serving TFA < TFA limit‡§	37	32	0·26	0·21, 0·31	0·38	0·25, 0·51	2	2, 3	12	33	0·23	0·12, 0·33	0·40	0·24, 0·56	2	1, 3
Foods exceeding TFA limit‡§	29	25	1·04	0·76, 1·32	2·97	2·00, 3·93	24	15, 32	11	31	1·61	1·19, 2·02	4·64	3·19, 6·08	22	16, 29**
Foods with HO†	766		0·24	0·20, 0·29	0·71	0·49, 0·93	4	3, 5	419		0·16	0·12, 0·21	0·63	0·30, 0·97	2	2, 3**
Foods ≤ 0 g/serving TFA	394	51	0	n/a	0	n/a	0		239	57	0	n/a	0	n/a	0	
Foods > 0 g/serving TFA < TFA limit‡§	229	30	0·21	0·19, 0·23	0·30	0·27, 0·33	2	2, 2	140	33	0·18	0·15, 0·20	0·28	0·25, 0·31	2	1, 2**
Foods exceeding TFA limit‡§	142	19	0·97	0·79, 1·15	3·20	2·20, 4·21	18	16, 20	40	10	1·10	0·74, 1·46	5·75	2·52, 8·99	18	15, 22
Foods without TFA declaration‖	1															
Foods with PHO, HO and/or both†	871		0·26	0·22, 0·30	0·74	0·54, 0·93	5	4, 5	450		0·19	0·14, 0·24	0·69	0·38, 1·01	3	2, 3**
Foods ≤ 0 g/serving TFA	439	50	0	n/a	0	n/a	0		251	56	0	n/a	0	n/a	0	
Foods > 0 g/serving TFA < TFA limit‡§	262	30	0·22	0·20, 0·24	0·31	0·28, 0·34	2	2, 2	150	33	0·18	0·16, 0·20	0·29	0·25, 0·32	2	1, 2**
Foods exceeding TFA limit‡§	169	19	0·98	0·83, 1·14	3·19	2·33, 4·06	19	17, 21	49	11	1·20	0·89, 1·51	5·55	2·94, 8·16	19	16, 22
Foods without TFA declaration‖	1															

TFA, trans fatty acids; FLIP, food label information program; PHO, partially hydrogenated oils; HO, hydrogenated oils; NFt, Nutrition Facts table.
*Mean TFA (g/serving) as declared on the NFt. In Canada, products with more than 0·2 g per serving of trans fat must declare trans fats on the label[19].
†Foods with partially hydrogenated oils, hydrogenated oils and/or both declared in the Ingredient List.
‡TFA limits were set at <2 % total fat for fats and oils and <5 % total fat for all other foods for the percentage calculated as TFA (g) to total fat (g)[61]. Values were calculated from the TFA declared on the NFt.
§In 2018, the use of PHO in foods was prohibited in Canada[63].
‖TFA data not available on the NFt.
**Mann–Whitney–Wilcoxon statistically significant at $P < 0·05$ between years.

concerning as a third of products with PHO in 2017 belonged to this category. We also found that in products exceeding limits, the levels of TFA were considerably higher compared with recommended limits of <5 % TFA of total fat for foods. For example, the percentage of TFA in relation to total fat for products with PHO, HO and/or both in 2017 was 19 %. Our assessment of the mean TFA content of products with HO, and particularly those exceeding recommended limits, suggests that such products are most likely products manufactured with PHO, although not labelled as such in the Ingredients List. Oils that have near-complete hydrogenation present similar TFA concentrations as those non-hydrogenated (i.e. <2 % of total fat)[45]. Thus, more work is needed to achieve the WHO recommendation of eliminating trans fats due to their harmful health effect and it is likely that banning the use of PHO would result in a further reduction of TFA, as seen in other countries where similar approaches have been taken[17,33,74–77]. Our results also highlight that monitoring the prevalence of HO and their TFA content in foods remains critical to assess unintended consequences, such as substantially higher levels of TFA in foods exceeding recommendations, a phenomenon observed in the present study, and particularly as the current labelling regulations do not require to differentiate between levels of hydrogenation[64].

Strength of this study is the use of a large database of food labels available in Canada (which includes the Ingredients List) that allowed us to evaluate the presence of PHO and HO in many food categories and to assess progress overtime resulting from voluntary efforts. Data regarding the prevalence of the use of PHO and especially HO in foods have been limited in Canada and elsewhere; thus, this research also highlights the importance of monitoring the use of HO in foods. Limitations of this study include that it is not possible to distinguish in the NFt the amount of TFA derived from each source (i.e. PHO/HO or ruminant sources). However, using the Ingredients List to identify food containing PHO and HO, we were able to establish a relationship between the presence of such oils and TFA in foods. Another limitation is that we only identified fats and oils that explicitly mentioned if they were 'partially hydrogenated' or 'hydrogenated', but certain fats and oils such as margarine, shortening or lard are exempted from declaring subcomponents (i.e. ingredients of ingredients) when they are used as ingredients in a product[78]; therefore, these fats could also contain PHO or HO. Additionally, the overall decrease in proportion of foods with TFA could have been attenuated because we included all foods available in our database, which also has foods that are not potential sources of TFA, and which prevalence could fluctuate overtime. However, we have tried to moderate this limitation by including analyses by food category. A final limitation is differences in food categorisation, which may restrict comparisons between countries.

Conclusions

The use of PHO, a major contributor of TFA in processed foods, continues to be present in the Canadian marketplace, despite voluntary efforts to eliminate it. Foods containing HO should also be monitored, as the TFA content of such products could exceed, in some cases, recommended limits. The action taken by the Canadian government to restrict the use of PHO will likely further reduce TFA in the Canadian food supply to negligible levels, thereby ensuring maximal health benefits for all segments of the population.

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analyses. B.F.-A and J.A. drafted the manuscript. All authors contributed to the revision of the final manuscript. *Ethics of human subject participation*: Not applicable.

Supplementary material

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References

1. Mozaffarian D, Katan MB, Ascherio A *et al.* (2006) Trans fatty acids and cardiovascular disease. *N Engl J Med* **354**, 1601–1613.
2. de Souza RJ, Mente A, Maroleanu A *et al.* (2015) Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. *BMJ* **351**, h3978.
3. Ganguly R & Pierce GN (2012) Trans fat involvement in cardiovascular disease. *Mol Nutr Food Res* **56**, 1090–1096.
4. Stender S, Astrup A & Dyerberg J (2008) Ruminant and industrially produced trans fatty acids: health aspects. *Food Nutr Res* **52**.
5. Jakobsen MU, Overvad K, Dyerberg J *et al.* (2008) Intake of ruminant trans fatty acids and risk of coronary heart disease. *Int J Epidemiol* **37**, 173–182.
6. Gebauer SK, Chardigny JM, Jakobsen MU *et al.* (2011) Effects of ruminant trans fatty acids on cardiovascular disease and cancer: a comprehensive review of epidemiological, clinical, and mechanistic studies. *Adv Nutr* **2**, 332–354.
7. Stender S (2015) In equal amounts, the major ruminant trans fatty acid is as bad for LDL cholesterol as industrially produced trans fatty acids, but the latter are easier to remove from foods. *Am J Clin Nutr* **102**, 1301–1302.
8. Gebauer SK, Destaillats F, Dionisi F *et al.* (2015) Vaccenic acid and trans fatty acid isomers from partially hydrogenated oil both adversely affect LDL cholesterol: a double-blind, randomized controlled trial. *Am J Clin Nutr* **102**, 1339–1346.
9. L'Abbé MR, Stender S, Skeaff CM *et al.* (2009) Approaches to removing trans fats from the food supply in industrialized and developing countries. *Eur J Clin Nutr* **63**, S50–S67.
10. Hernandez EM & Kamal-Eldin A (2013) Current processing techniques for fats and oils. In *Processing and Nutrition of Fats and Oils*, pp. 83–107. USA: John Wiley & Sons, Ltd.
11. European Union (2015) Report from the Commission to the European Parliament and the Council regarding trans fats in foods and in the overall diet of the Union population. https://ec.europa.eu/food/sites/food/files/safety/docs/fs_labelling-nutrition_trans-fats-report_en.pdf (accessed May 2018).
12. Government of Denmark – Ministry of Environment and Food. Danish Veterinary and Food Administration (2003) Bekendtgørelse om indhold af transfedtsyrer i olier og fedtstoffer m.v. [Legislation on the content of trans fatty acids in oils and fats]. https://www.retsinformation.dk/Forms/R0710.aspx?id=175931 (accessed May 2018).
13. Uauy R, Aro A, Clarke R *et al.* (2009) WHO scientific update on trans fatty acids: summary and conclusions. *Eur J Clin Nutr* **63**, S68.
14. Mozaffarian D, Aro A & Willett WC (2009) Health effects of trans-fatty acids: experimental and observational evidence. *Eur J Clin Nutr* **63**, Suppl. 2, S5–S21.
15. World Health Organization Regional Office for Europe (2015) Eliminating trans fats in Europe: a policy brief. http://www.euro.who.int/__data/assets/pdf_file/0010/288442/Eliminating-trans-fats-in-Europe-A-policy-brief.pdf?ua=1 (accessed February 2019).
16. Colón-Ramos U, Monge-Rojas R & Campos H (2014) Impact of WHO recommendations to eliminate industrial trans-fatty acids from the food supply in Latin America and the Caribbean. *Health Policy Plan* **29**, 529–541.
17. Monge-Rojas R, Colón-Ramos U, Jacoby E *et al.* (2017) Progress towards elimination of trans-fatty acids in foods commonly consumed in four Latin American cities. *Public Health Nutr* **20**, 2440–2449.
18. Government of Brazil – Ministry of Health [Ministério da Saúde] (2001) Mandatory labelling [Rotulagem Nutricional Obrigatória].
19. Government of Canada (2003) Regulations amending the food and drug regulations (nutrition labelling, nutrient content claims and health claims). http://publications.gc.ca/gazette/archives/p2/2003/2003–01–01/pdf/g2–13701.pdf (accessed June 2018).
20. Rubinstein A, Elorriaga N, Garay OU *et al.* (2015) Eliminating artificial trans fatty acids in Argentina: estimated effects on the burden of coronary heart disease and costs. *Bull World Health Organ* **93**, 614–622.
21. Government of Uruguay – Ministry of Public Health (2006) Trans fat labelling [Decreto 117 – Reglamento Bromatologico Nacional].
22. Food and Drug Administration (2006) Code of Federal Regulations. Title 21 – Food and Drugs. Part 101.9 – Nutrition Labeling. https://www.gpo.gov/fdsys/pkg/CFR-2008-title21-vol2/xml/CFR-2008-title21-vol2-part101.xml (accessed March 2019).
23. Lee JH, Adhikari P, Kim SA *et al.* (2010) Trans fatty acids content and fatty acid profiles in the selected food products from Korea between 2005 and 2008. *J Food Sci* **75**, C647–652.
24. Government of Korea – Ministry of Food and Drug Safety Republic of Korea (2016 (Revised)) Food labeling system. http://www.mfds.go.kr/eng/index.do?nMenuCode=118 (accessed March 2019).
25. Comités Técnicos de Normalización y de Reglamentación Técnica de la Región Centroamericana [Technical Committees for Standardization and Technical Regulation of the Central American Region] (2010) Reglamento Técnico Centroamericano. Etiquetado general de los alimentos previamente envasados preenvasados [Central America Labelling Regulations for Prepackaged foods and beverages]. http://www.cita.ucr.ac.cr/sites/default/files/archivos_adjuntos/Reglamento%20Técnico%20Centroamericano%20de%20Etiquetado%20General%20de%20los%20Alimentos%20Preenvasados.pdf (accessed March 2019).
26. Government of Mexico – Ministry of Health [Secretaria de Salud de Mexico] (2010) NOM-051-SCFI/SSA1–2010 Nutrition Labelling – Trans fats Art.4.2.8.2.3 [NORMA Official Mexicana NOM-051-SCFI/SSA1–2010, Especificaciones generales de etiquetado para alimentos y bebidas no alcohólicas preenvasados-Información comercial y sanitaria].
27. Government of Hong Kong (2010) Food and drugs (composition and labelling) regulations – Schedule 5 Nutrition labelling and nutrition claim. https://www.elegislation.gov.hk/hk/cap132W?xpid=ID_1438402697315_002 (accessed February 2019).
28. Government of Bolivia – Ministry of Health [Ministerio de Pública de Bolivia] (2016) Ley 775 – Promocion de Alimentacion Saludable [Law 775 healthy eating – arts IV & V trans fat]. https://www.minsalud.gob.bo/images/Documentacion/normativa/LEY_775_ALIMENTACION%20SALUDABLE.pdf (accessed February 2019).
29. Government of Canada – Health Canada (2006) Final report of the trans fat task force. http://www.hc-sc.gc.ca/fn-an/nutrition/gras-trans-fats/tf-ge/tf-gt_rep-rap-eng.php (accessed May 28 2018).

30. World Health Organization (2009) WHO scientific update on Trans Fatty Acids (TFA). http://www.who.int/nutrition/publications/nutrientrequirements/scientific_update_TFA/en/ (accessed February 2019).
31. Government of Chile – Ministry of Health (First published 1997. Last Amended 2015) Reglamento Sanitario de los Alimentos [Food Labelling Law]. https://web.minsal.cl/sites/default/files/files/DECRETO_977_96%20actualizado%20a%20Enero%202015(1).pdf (accessed September 2017).
32. Government of Argentina – Ministry of Health (2010) Codigo Alimentario Argentino Capitulo III Artículo 155 tris [Argentinean Food Code Chapter III]. In Spanish. http://www.anmat.gov.ar/alimentos/codigoa/Capitulo_III.pdf (accessed May 2018).
33. Kakisu E, Tomchinsky E, Victoria Lipps M *et al.* (2018) Analysis of the reduction of trans-fatty-acid levels in the foods of Argentina. *Int J Food Sci Nutr*, 1–10.
34. Government of Austria -Bundesgesetzblatt fur Die Republik Österreich (2009) 267. Verordnung des Bundesministers für Gesundheit über den Gehalt an trans-Fettsäuren in Lebensmitteln (Trans-Fettsäuren-Verordnung). [Regulation of the Minister of Health on the content of trans-fatty acids in foods].
35. Government Offices of Iceland (2010) Reglugerð um hámarksmagn transfitusýra í matvælum [Regulation on maximum levels of trans fatty acids in foods]. https://www.stjornarradid.is/media/atvinnuvegaraduneyti-media/media/reglugerdir/Rgl-hamarksmagn-transfitusyra-i-matvaelum.pdf (accessed February 2018).
36. Government of Lithuania (2011) Requirements for the feeding of children in schools, families and children's social welfare institutions – Trans Fats – 17 & 18 [Dėl Maitinimo organizavimo ikimokyklinio ugdymo, bendrojo ugdymo mokyklose ir vaikų socialinės globos įstaigose tvarkos aprašo patvirtinimo].
37. Government of Sweden (2013) Riksdagens protokoll 2013/14:123. http://www.riksdagen.se/sv/dokument-lagar/dokument/protokoll/riksdagens-protokoll-201314123-onsdagen-den-11_H109123 (accessed March 2019).
38. Government of Singapore (2012) Sale of Food Act (CHAPTER 283, SECTION 56(1)) – S 175/2012 wef 02/05/2012. https://sso.agc.gov.sg/SL/SFA1973-RG1?DocDate=20120903&ValidDate=20161012&TransactionDate=20161012 (accessed May 2018).
39. Government of Colombia – Ministry of Health (2012) Resolución N°2.508, Reglamento técnico sobre los requisitos que deben cumplir los alimentos envasados que contengan grasas trans y/o grasas saturadas [Technical regulation on the requirements for packaged foods containing trans fat and / or saturated fat]. https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/DE/DIJ/Resolucion-2508-de-2012.PDF (accessed February 2018).
40. Government of Hungary (2013) 71/2013. (XI. 20) EMMI rendelet. az élelmiszerekben lévő transz-zsírsavak megengedhető legnagyobb mennyiségéről, a transz-zsírsav tartalmú élelmiszerek forgalmazásának feltételeiről és hatósági ellenőrzéséről, valamint a lakosság transz-zsírsav bevitelének nyomon követésére vonatkozó szabályokról [Regulation on maximum permitted levels of trans fatty acids in foodstuffs, conditions and official controls for the marketing of food containing trans fatty acids and rules for monitoring the intake of trans fats by the general public]. https://net.jogtar.hu/jr/gen/hjegy_doc.cgi?docid=a1300071.emm (accessed May 2018).
41. Government of Ecuador – Ministry of Public Health [Ministerio de Salud Pública de Ecuador] (2013) Acuerdo ministerial No. 00004439 – Límites máximos de grasas trans en grasas y aceites comestibles, margarinas e insumos para las industrias de alimentos, panaderías, restaurantes o servicios de comidas [Maximum trans fat limits in edible fats and oils, margarines and supplies for the food industries, bakeries, restaurants or food services]. https://extranet.who.int/nutrition/gina/en/node/23225 (accessed February 2018).
42. Government of Norway – Ministry of Health and Care Services [Helse- og omsorgsdepartementet] (2014) Forskrift om transfettsyrer i næringsmidler [Regulations on trans fatty acids in foods]. https://lovdata.no/dokument/SF/forskrift/2014-01-16-34?q=Forskrift%20om%20transfettsyrer%20i%20n%C3%A6ringsmidler (accessed February 2018).
43. Government of Mexico – Ministries of Health and Education (2014) ACUERDO mediante el cual se establecen los lineamientos generales para el expendio y distribución de alimentos y bebidas preparados y procesados en las escuelas del Sistema Educativo Nacional [Agreement establishing the general guidelines for the sale and distribution of prepared and processed food and beverages in the schools of the National Educational System]. http://www.dof.gob.mx/nota_detalle.php?codigo=5344984&fecha=16/05/2014 (accessed May 2018).
44. Government of Uruguay – Ministry of Public Health [Ministerio de Salud Pública] (2014) Lineamientos para la venta y publicidad de alimentos en centros de enseñanza primaria y secundaria públicos y privados del país [Guidelines for the sale and advertising of food in public and private primary and secondary schools in the country]. http://www.msp.gub.uy/sites/default/files/archivos_adjuntos/Lineamientos_nutricionales_para_%20la_venta_%20de_%20alimentos_en_centros_educativos_v2.pdf (accessed May 2018).
45. Food and Drug Administration (2015) Federal register: final determination regarding partially hydrogenated oils. https://www.federalregister.gov/documents/2015/06/17/2015–14883/final-determination-regarding-partially-hydrogenated-oils (accessed March 2019).
46. Government of India – Ministry of Health and Family Welfare (2015) Amendment to food products standards and food additives – trans fats.
47. Republic of Latvia (2017) Legislation on trans fatty acids in Latvia. http://efsa.vmvt.lt/content/uploads/2017/09/Lasma-Pikele-Latvijos-sveikatos-ministerija.pdf (accessed May 2018).
48. USDA Foreign Agricultural Services (2016) Jordan bans partially hydrogenated oil in dairy products.
49. Government of Canada – Health Canada (2017) Notice of modification: prohibiting the use of partially hydrogenated oils in foods. https://www.canada.ca/en/health-canada/services/food-nutrition/public-involvement-partnerships/modification-prohibiting-use-partially-hydrogenated-oils-in-foods.html (accessed September 2017).
50. Government of Brazil – Ministry of Health [Ministério da Saúde] (2017) Ban of the use of partially hydrogenated vegetable fats in the manufacture of food. https://legis.senado.leg.br/sdleg-getter/documento?dm=5299968&disposition=inline (accessed May 2018).
51. USDA Foreign Agricultural Services (2019) Thailand bans the use of partially hydrogenated oils in foods. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Thailand%20Bans%20the%20Use%20of%20Partially%20Hydrogenated%20Oils%20in%20Foods_Bangkok_Thailand_8–2–2018.pdf (accessed February 2019).
52. World Health Organization (2018) Replace trans fats. http://www.who.int/docs/default-source/documents/replace-transfats/replace-country-information-sheet.pdf?sfvrsn=5691fd0d_4 (accessed February 2019).
53. World Health Organization (2018) Draft guidelines on saturated fatty acid and trans-fatty acid intake for adults and children. https://extranet.who.int/dataform/upload/surveys/666752/files/Draft%20WHO%20SFA-TFA%20guidelines_04052018%20Public%20Consultation(1).pdf (accessed February 2019).
54. World Health Organization (2019) Countdown to 2023: WHO report on global trans fat elimination 2019. https://

https://doi.org/10.1017/S1368980019004816 Published online by Cambridge University Press

www.who.int/docs/default-source/documents/replace-transfats/report-on-tfa-elimination-2019.pdf?sfvrsn=c9378613_4 (accessed May 2020).
55. European Commission (2019) COMMISSION REGULATION (EU) 2019/649 of 24 April 2019 amending Annex III to Regulation (EC) No 1925/2006 of the European Parliament and of the Council as regards trans fat, other than trans fat naturally occurring in fat of animal origin. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0649&from=EN (accessed April 2019).
56. Downs SM, Thow AM & Leeder SR (2013) The effectiveness of policies for reducing dietary trans fat: a systematic review of the evidence. *Bull World Health Organ* **91**, 262–269H.
57. Hendry VL, Almíron-Roig E, Monsivais P *et al.* (2015) Impact of regulatory interventions to reduce intake of artificial trans-fatty acids: a systematic review. *Am J Public Health* **105**, e32–e42.
58. Hyseni L, Bromley H, Kypridemos C *et al.* (2017) Systematic review of dietary trans-fat reduction interventions. *Bull World Health Organ* **95**, 821–830G.
59. Downs SM, Bloem MZ, Zheng M *et al.* (2017) The impact of policies to reduce trans fat consumption: a systematic review of the evidence. *Curr Dev Nutr* **1**.
60. Ratnayake WM & Chen ZY (1996) Trans, n-3, and n-6 fatty acids in Canadian human milk. *Lipids* **31**, Suppl., S279–S282.
61. Government of Canada – Health Canada (2009) Trans fat monitoring program. https://www.canada.ca/en/health-canada/services/nutrition-science-research/food-nutrition-surveillance/trans-fat-monitoring-program.html (accessed May 2018).
62. Arcand J, Scourboutakos MJ, Au JT *et al.* (2014) Trans fatty acids in the Canadian food supply: an updated analysis. *Am J Clin Nutr* **100**, 1116–1123.
63. Government of Canada – Health Canada (2017) Notice of proposal – prohibiting the use of partially hydrogenated oils (PHOs) in foods. http://www.hc-sc.gc.ca/fn-an/consult/nop-adp-c-2017–3/nop-adp-c-2017–3-eng.php– (accessed May 2018).
64. Canadian Food Inspection Agency (2003) Labelling requirements for fats and oils. https://www.inspection.gc.ca/food/requirements-and-guidance/labelling/industry/fats-and-oils/eng/1392751693435/1392751782638?chap=0 (accessed February 2019).
65. Schermel A, Emrich TE, Arcand J *et al.* (2013) Nutrition marketing on processed food packages in Canada: 2010 food label information program. *Appl Physiol Nutr Metab* **38**, 666–672.
66. Bernstein JT, Schermel A, Mills CM *et al.* (2016) Total and free sugar content of Canadian prepackaged foods and beverages. *Nutrients* **September**, E582.
67. USDA Foreign Agricultural Services (2018) Canada retail sector overview – 2018. https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Retail%20Foods_Ottawa_Canada_6–26–2018.pdf (accessed February 2019).
68. Health Canada (2015) Canadian nutrient file. http://www.healthcanada.gc.ca/cnf (accessed May 2018).
69. Health Canada (2016) Table of reference amounts for food. https://www.canada.ca/en/health-canada/services/technical-documents-labelling-requirements/table-reference-amounts-food.html (accessed February 2019).
70. The R Foundation for Statistical Computing (2002) R Statistical software package. https://www.r-project.org (accessed February 2019).
71. Costa N, Cruz R, Graça P *et al.* (2016) Trans fatty acids in the Portuguese food market. *Food Control* **64**, 128–134.
72. Becker W, Eriksson A, Haglund M *et al.* (2015) Contents of total fat, fatty acids, starch, sugars and dietary fibre in Swedish market basket diets. *Br J Nutr* **113**, 1453–1465.
73. Zupanič N, Hribar M, Pivk Kupirovič U *et al.* (2018) Limiting trans fats in foods: use of partially hydrogenated vegetable oils in prepacked foods in Slovenia. *Nutrients* **10**, 355.
74. Otite FO, Jacobson MF, Dahmubed A *et al.* (2013) Trends in trans fatty acids reformulations of US supermarket and brand-name foods from 2007 through 2011. *Prev Chronic Dis* **10**, E85.
75. Moynihan M, Villamor E, Marin C *et al.* (2015) Trans-fatty acids in cooking oils in Bogota, Colombia: changes in the food supply from 2008 to 2013. *Public Health Nutr* **18**, 3260–3264.
76. Brouwer I (2016) Effect of trans-fatty acid intake on blood lipids and lipoproteins: a systematic review and meta-regression analysis. http://apps.who.int/iris/bitstream/10665/246109/1/9789241510608-eng.pdf (accessed December 2017).
77. Pearson-Stuttard J, Critchley J, Capewell S *et al.* (2015) Quantifying the socio-economic benefits of reducing industrial dietary trans fats: modelling study. *PLoS One* **10**, e0132524.
78. Canadian Food Inspection Agency (2003) List of ingredients and allergens manner of declaring. https://www.inspection.gc.ca/food/requirements-and-guidance/labelling/industry/list-of-ingredients-and-allergens/eng/1383612857522/1383612932341?chap=2 (accessed February 2019).

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